NATIONAL ENGINEERING ROBOTICS CONTEST 2023

THEME: INDIGENOUS CATEGORY

National Engineering Robotics Contest

A joint venture of NUST and STEM Careers Programme (HEC)

Organized by:

Department of Mechatronics Engineering,

College of Electrical and Mechanical Engineering (CEME),

National University of Sciences and Technology (NUST), Islamabad, Pakistan

&

National Centre of Robotics and Automation (NCRA)

CHANGE LOG

The table below will list the pages on which changes have been made to the theme.

Revision Date	

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NOTE:

1. Any correspondence with the NERC officials via e-mail, telephone, or any other means will not be considered as part of the rules (unless uploaded as an FAQ on official NERC website).
2. In all matters of interpreting the rules before and during the Contest and in any issues not covered by these rules, the decisions of the Contest Judging Committee will be considered final.

CONTENTS

1 INTRODUCTION

The National Engineering Robotics Contest (NERC) is a joint project of the National University of Sciences and Technology (NUST) and science technology STEM Careers Program HEC to promote research in the field of robotics and its related fields in Pakistan. We, from the Department of Mechatronics Engineering, welcome you all to participate in 19th National Engineering Robotics Contest (NERC 2023). This competition will provide a common platform for the integration and evaluation of various electromechanical designs, control and path planning algorithms, and agent architectures.

Over the years, NERC has grown increasingly popular among students as well as engineering departments across the country. The Engineering students from all over Pakistan participate in this competition. Many students participate in this contest in their final years of undergraduate degree and take the contest theme as their Final Year Project thus becoming part of human resource required in field of robotics and automation. This not only adds value to the competition but also resolves our pledge to bring exciting new challenges every year for the advancement of robotics community at an increasingly wider scale. Robotics is a buzz word at today's technology forefronts. Due to exponential advancements in fields like high performance computing, computer vision, computer networks, material sciences and power electronics, the growth experienced by robotics in past few years is unprecedented. Robotics is the only field which can add precision while replacing the slow manual labor in the contemporary industrial world. Thus, this field faces enormous pressure from industry to produce all-purpose mobile manipulator robots which can perform simple tasks like grab, navigate and place objects at desired locations autonomously. The future of Pakistan relies heavily on advancement in the fields of engineering and science and events of this nature will encourage and motivate students to improve their technical skills in leaps and bounds. The focus of NERC 2023 theme is to create an autonomous robot that can simulate Fruit Harvesting tasks. In this theme, there will be a robot that is acting as the harvester robot. Its job is to pluck and collect the fruits (ping pong balls) from the trees based on the color indicated on plate. After collecting all the fruits, the robot shall drop them at designated area and shall reach a parking spot. The first team to successfully collect all the fruits and reach the parking spot will be declared winner.

2 CATEGORIES

There are two categories of the contest:

- Indigenous Robot category
- Modular Robot category.

The purpose of this contest is to develop a sense of problem-solving, project- based learning, team-based learning, technical design and ingenuity among the contestants.

2.1 INDIGENOUS ROBOT CATEGORY

Indigenous category includes robots that are constructed from scratch. Their mechanical structure, controls etc. are designed by the teams themselves. The electronic control modules including all electronic boards and motor drivers (Unless specified otherwise) etc. should be designed and manufactured by the students.

2.2 MODULAR ROBOT CATEGORY

Modular/Lego category includes robots that are developed using ready-made kits for example Lego, EV3 kits, EDVON kits or NCRA robotic kit. The Modular category is further divided into two subcategories:

2.2.1 Modular School

2.2.1.1 *Lego School*

2.2.1.2 *Ready to Race School*

2.2.2 Modular University

2.2.2.1 Lego University

2.2.2.2 Ready to Race University

This document describes the theme only for Category 1 – Indigenous Robots

3 CONTEST STRUCTURE

The contest will consist of two stages:

1. Heats/Qualifying Rounds
2. Head to head matches

3.1 QUALIFYING ROUNDS

Each robot will participate in the qualifying rounds (heats). There will be no head-to-head matches in heats. For qualifying rounds following rules will be observed:

3.1.1 There will be NO head-to-head matches. Each team will individually run their robots.

3.1.2 Seeding chart will be based on points scored by teams. If the points of both teams are equal, decision will be made based on time taken by both teams. The team with shortest time will be placed on higher seed position. If time of both teams is also same, the decision

of the higher seed will be based on the shortest distance from the next objective from the current position (as per discretion of judges). If all the above criteria are the same, coin toss by judges will decide higher seed position.

3.1.3 Each team will be provided with maximum of 3 minutes to run their Robot. A timer will be displayed for the audience, however, accurate time through the stopwatch will be recorded by jury.

3.1.4 A team can take as many retries as desired within 3 minutes without any penalty but only the total time taken, and final score will be recorded. (Refer to the section 7.9, **Retry** For further details)

3.1.5 When the team takes a retry the score is reset to zero and the entire arena will be reset.

3.1.6 When the team is ready, and the whistle is blown, time will be started.

3.1.7 If a robot is not able to successfully complete the task in time, then the time when team's flag bearer will call it off (By saying "STOP") will be recorded as the finish time.

3.1.8 Only the **flag bearer** has the right to say **Retry/Stop.**

3.1.9 Judges reserves the right to give a re-run to any team with zero score with justifiable reason (if required).

3.1.10 If the robots complete all tasks successfully and crosses the finish line (scoring maximum point), the stop called by the flag bearer will be of no importance/significance.

3.2 Head-to-head Matches

After qualifying rounds, the top 32 teams (with non-zero score) from the qualifying rounds will go on into the final rounds for head-to-head matches. The judges reserve the right to change top 32 teams. The winners will be decided through a final match and Runner-up will be decided based on the outcomes of the semifinals and quarter finals.

4 Contest Theme

The NERC 2023 theme is continuation of 2022 based on precision agriculture with focus on autonomous robots that can simulate Fruit Harvesting tasks. In this theme, there will be a robot that is acting as the harvester robot, its job is to pluck only riped fruits from the tree. The ripe and unripe fruits are represented with orange and green colored ping pong balls respectively. After collecting the desired fruits, the robot shall drop them at the designated area and shall reach the parking spot. The first team to successfully collect all the desired fruits and reach the parking spot will be declared the winner. The Contest arena is shown in Figure 1.

1. Laminated wooden sheets (lasani) are used for the construction of the arena. The floor of

arena will be of white color as shown in the map.

2. The solid black lines and dashed lines in Figure 1, represent the walls of the arena. The walls represented by solid black lines have a height of 4 inches throughout the arena. The walls represented by dashed black lines have a height of 2 inches throughout the arena.

3. The red dotted lines in Figure 1. represent the black solid lines on the arena. The unloading bay is represented by B.
4. The entire arena is divided into **8x8 inch** grids. Each grid is assigned a row and a column number. This grid is not represented as lines on the arena. It is for reference positions only, and grid lines number are not marked on fabricated arena.

5. The robot (R1) will start at the intersection of grid lines (4,5) and (9,10) facing in the direction of the arrow as marked in Figure 1. The starting position and orientation of the robot (R1) are fixed. The robot must be placed behind the starting line.

6. The red line on the figure adjacent on R1 shows the starting point of the Robot. The Robot will be placed behind the starting line whereas, wheels may be at different position. The line following sensor should also be behind the line.

7. The Robot may follow the black line (Reflective Tape) or Wall of the arena to locate the Trees.

8. The fruits are considered to be ping pong balls of Green and Orange colors.

9. The fruits are hanged with the branch of trees shown in Annex C.

10. The maturity states(ripe/unripe) of fruits on each tree is represented by two things on the arena:
    i. The color of the ping pong ball representing the fruits. The orange ball represents the riped fruits and green represents the unriped fruits.
    ii. A label present in front of each tree will give you the status of fruits i-e ripe/unripe (present on the wall as shown in figure4) having dimension of 4x4 inches (excluding the frame).

11. The robot (R1) will reach the location of the tree and collect the desired ripe fruits from the tree and will put all the collected fruits in the unloading bay(B).

12. After successful collection of all the ripe fruits and dropping them in unloading bay(B), the robot(R1) will move towards the Parking spot as marked in the arena shown in Figure 1. The team to successfully complete all the tasks and reach the parking spot will be declared the winner. A successful reach means all the parts of the robots have crossed the parking entrance line and no part is on and above the line.

13. There will be total of 6 balls, the placement & quantity of ripe balls can be varied in any match, the representation of the tree is shown in the Annex C

14. After the start of the match, the team cannot touch the robot(R1).

15. Each team must bring their own robot(R1).

16. In case of a retry, the teams can reset their robots.

17. The maximum dimension of the robot is 10x10 inches (LxW).

18. The robot should be an autonomous and indigenously developed robot.

19. The programming of the Robot is allowed only in allotted 3 minutes time, it is not allowed once a match has started.

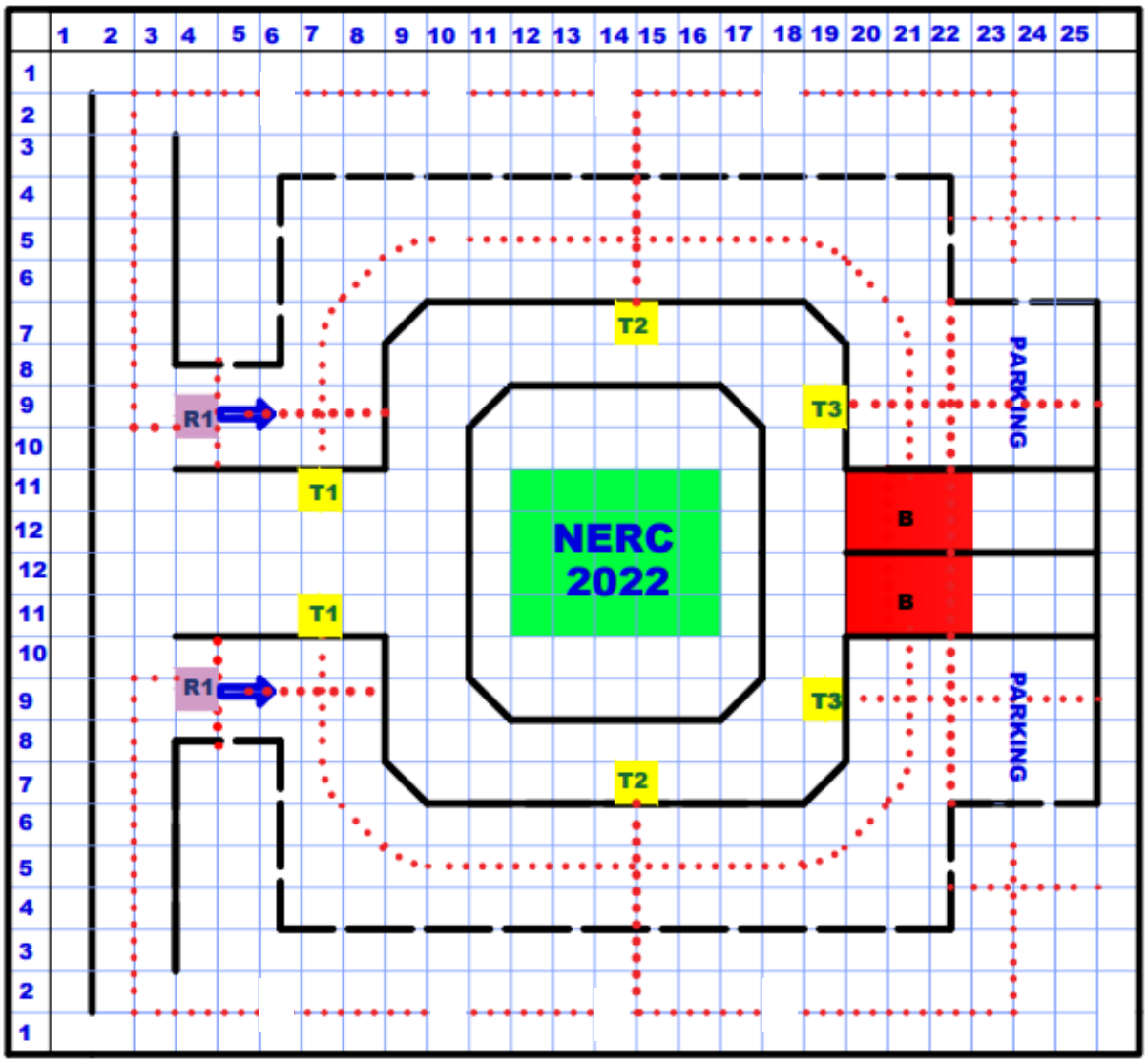

Figure 1 Contest Arena (Top View)

- *Each grid is of 8x8 inches (The grid lines are for reference only and will not be marked on the actual arena)*
- *Red Dotted Line indicates solid line with black tape*
- *T1, T2 and T3 are tree positions*
- *B is the unloading Bay*
- *Grid is only for reference, it will not be marked on the arena*
- *Both sides are mirrored images*

5 ROBOT OPERATION

The qualifying teams (those which qualify for the final rounds) will compete with each other in a knockout format. In each match two teams will be pitted against each other, running their robots' side by side in the contest arena. Teams will be declared as Team A or Team B based on the coin toss before every match. The winner of coin toss will decide which arena to choose.
Team A will run their robot on the left side and Team B will run their robot right side.

Once turned on, the robot must be self-controlled without any human intervention. Contestants are NOT allowed to touch their robots. After the blow of a whistle, the robot will have 3 minutes to complete the task.

During a retry, the layout of the arena shall remain SAME however the point-scoring will restart from zero. The robot may navigate through the arena using any suitable technique. The robot may not displace any item in the arena. Displacing any item inside the arena will result in a forced retry(Judges decision on declaring a displacement will be final). If the participating team sees that their robot has lost track of its location and is facing trouble localizing itself, the team can ask for a retry. During its motion, the robot may touch the walls of the arena without damaging them, but it is not allowed to use any sort of tactile sensor to sense the walls or obstacles. This will result in forced retry or disqualification (as per discretion of judges).

In case of a tie, the contestant may be required to run a rematch, or the winner may be decided on a coin toss as per the discretion of the judges.

For a particular match, both teams will face the same layout of the arena.

6 POINTS

The point scoring is shown below in Table 1 Point Scoring.

Table 1 Point Scoring

Tasks(Scenerio-1): Each Tree has two Ripe Balls	**Score**
Loading the desired balls from T1 (10 points per ball) (Each ball carries equal marks)	20
Loading the desired balls from T2 (10 points per ball) (each ball carries equal marks)	20
Loading the desired balls from T3 (10 points per ball) (each ball carries equal marks)	20
Transfer all 6 balls of T1, T2, T3 to the unloading bay (5 points per ball) (each ball carries equal marks)	30
Reaching the Parking	10
Total	100

*****Reaching means the robot **must have completely entered the parking area** as shown in the fig 1 (red dotted line represented as black marker in col 22 of figure 1)

6.1 DEDUCTION OF POINTS

The deduction of points is shown below in Table 2. Deduction of Points

Table 2. Deduction of Points

	Deduction/Penalty
Loading Unriped Ball from any Tree	5 points per Ball
The robot fits in an area of 10x 10-inch square	No Penalty
Oversize Robot (12x12 inch square)	5 Points
Oversize Robot (exceeding 12 x 12-inch square)	Disqualification
Robots weighs less than 12 kg*	No Penalty
Overweight Robots (Weight between 12 and 14 kg)	5 Points
Overweight Robots (Weight exceeding 14 kg)	Disqualification
Damaging the arena/wall/sites/ramp	Disqualification

*This is the individual weight of each robot

7 RULES

The following are the rules governing the contest.

7.1 GENERAL

7.1.1 The Contest judges may stop any robot at any time if they feel that it is performing, or is about to perform, any action that is dangerous or hazardous to people or equipment.

7.1.2 All electronic circuitry must be designed and fabricated by the contestants themselves.

7.1.3 Maximum effort in the design and fabrication of the robot shall be done by the contestant themselves.

7.1.4 Contestants are allowed to use only certain electronic components, list for which is attached at the end of this document.

7.1.5 Additional information regarding the contest rules and regulations may be found in the words of FAQs(https://nerc.ceme.nust.edu.pk) and will be considered as part of the theme and rules. New FAQs are uploaded frequently so keep watching the FAQ corner for new information.

7.1.6 Any correspondence with the NERC officials via e-mail, telephone or any other means will not be considered as part of the rules (unless uploaded as an FAQ on official NERC (website). It is the responsibility of the contest to be familiar with all the rules.

7.1.7 If both the teams have scored same points but are not able to complete the task in allocated time slot decision of the winner will be on judges' discretion who will determine which robot is closer to finish the task first.

7.1.8 If both teams have scored the same points, have the same time and are at the same distance from the finish point, a coin toss will be used to decide the winner.

7.1.9 If any team wants to launch a protest (of any kind), they must do so within 15 minutes of the end of their match. The procedure and payment is outlined in Anx B.

7.1.10 Attempting to damage the game field or performing an act that fails to comply with the spirit of Fair Play will lead to the disqualification of the team.

7.1.11 In all matters of interpreting the rules before and during the Contest and in any issues not covered by these rules, the decisions of the Contest Judging Committee will be final.

7.2 TEAMS

7.2.1 The Robots can be built by teams of currently registered students from Engineering Institutions and Polytechnic Institutions. Each team can comprise of a ***maximum 6 members***.

7.2.2 If the students from two different Institutes/Universities join hands and form a team in collaboration, then the name of the Institute/University with maximum number of students in such a team would be registered or official consent from both institutions will be required at the time of registration before the contest start date.

7.2.3 A person can't participate in more than two teams

7.3 ROBOT SIZE AND WEIGHT

The robot fits within 10x 10-inch square at the time of measurement. If the area of the robot base is more than 10x 10-inch square but less than 12 X 12- Inch square, then points will be deducted. There is no restriction on the maximum permissible height of the robot. Any robot which does not fit in 14X14-Inch square will be disqualified. All robots will be carefully measured. All sensors mounted on the robot will be counted as part of the robot's total dimensions. If contestants want to add a flag, hat or other purely decorative, non-functional items to the robot, they may do so. The decorations may be removed for measurement purposes. The weight of each robot excluding decorations must not exceed 12 kg. Penalties as detailed in 6.1 Deduction of Points will be levied if the robot does not fulfill the size and/or weight criteria.

7.4 ROBOT OPERATION

7.4.1 Any team that damages the arena will be disqualified.

7.4.2 The robot must not use any harmful substances such as oil, petrol etc. in its operation that can damage the arena.

7.4.3 The Robot CANNOT split after the start of the game, only one Robot is allowed to compete at a time.

7.4.4 The robot must not use any destructive or dangerous methods to displace any obstacle or box.

7.5 SENSORS

7.5.1 Robot is not allowed to use tactile sensor of any type for sensing the Walls.

7.5.2 Ultra-Sonic Range detectors (SONARs) or IR based proximity sensors (models specified in the components' list attached) must be used for sensing walls/Line.

7.5.3 The team may use any off-the-shelf encoders if they feel the necessity. Self-made encoders from discrete components are also allowed.

7.6 ELECTRONICS

7.6.1 All electronic circuitry must be designed and fabricated completely by the participants themselves. Circuits should not be fabricated by the help of any professionaldevelopers. Only the modules specified in the components list may be bought directly.

7.6.2 The participants must not use any pre-fabricated board or electronic circuitry. Any type of the electronic board or circuit must be etched by the students themselves. Circuits should not be fabricated by the help of any professional developers.

7.6.3 Any type of the electronic board or circuit must be etched by the students themselves. Circuits should not be fabricated by the help of any professional developers

7.6.4 Microcontrollers specified in the component list must be used for controlling your robots. You can also use Microcontroller development boards specified in the list only. Microprocessors and Single Board Computers are not allowed.

7.6.5 Motor drive circuits should be designed and fabricated by participants themselves and made from discrete components like Transistors and logic circuitry. H-bridge IC's like L297 or L298 are not allowed. However, you may use Gate driver IC's e.g. IR2101/IR2110 etc.

7.6.6 No prefabricated modules are allowed, unless listed in the components list or allowed by the NERC coordinator. If a component needs to be added then all of its specification (datasheet, picture, location to purchase, price) MUST be emailed for formal permission.

7.6.7 All other components can be used in your circuitry. In case of any query, questions shall be emailed to NERC Coordinator at nerc@ceme.nust.edu.pk . The FAQs section on the website shall be considered part of the theme.

Note: Only the theme documents and the questions in the FAQ section of the official website (nerc.ceme.nust.edu.pk) shall be considered as official notifications.

7.7 POWER SUPPLY

7.7.1 The robot must be battery-powered.

7.7.2 The robot must not have any wired connections with its surroundings.

7.7.3 Voltage of the machine's electrical power source must not exceed 48-volt DC. **Power banks may be used.**

7.7.4 Power sources that are considered dangerous or unsuitable by the contest Officials shall not be permitted.

7.8 Duration of Match

7.8.1 Each match will be of maximum 3 minutes.

7.8.2 Teams will be given around 1 minute for setting up the Robot at the start.

7.8.3 Robot can start at the instant when the start signal is given and a whistle is blown. The Robot should be constructed so that it can be started in minimum possible steps.

7.8.4 Once the Robot moves, team members will not be allowed to touch the Robot or enter the Contest Arena. If any team member enters, forced retry shall be imposed.

7.8.5 Timing shall start once the start signal is given and the whistle is blown.

7.8.6 Time would be stopped as soon as Robot R1 reaches the parking spot B. If a robot is not able to successfully complete the task then the time when team will call it off will be recorded as the finish time. The team must leave their robots as it is on their current locations when time stop is called by them. They may NOT pick their robots up till the referee announces the end of the match. The team is not allowed to take a retry after the time has stopped.

7.8.7 The team which harvests all the fruits, put them in unloading bay(B) and then reaches the parking spot will be declared the winner of the match.

7.8.8 If both teams fail to complete the task, within the time limit, the team scoring more points will be declared the winner of the match.

7.8.9 If both the teams have scored same points but are not able to complete the task in allocated time slot, then decision of the winner will be on judges' discretion who will determine which robot is closer to finish the task first. The distance of the robot's current location from the Finish Point (Parking Spot) will be measured.

7.8.10 Crossing the parking line, no parts hanging

7.9 Retry

If the robot is strayed due to some reason, retries are allowed.

7.9.1 There is no limitation on the number of retries and a team can take as many retries within the 3 minutes duration of the match. No Points will be deducted for retries but total score will reset to zero.

7.9.2 Each team would be provided a flag of their respective team. If a team wants to take a retry, the flag bearer must raise the flag and say clearly "retry". Once the referee announces a retry, the team shall place its robots at their starting location

7.9.3 If a team wants to stop their robot during the match, the flag bearer must raise the flag

and say “stop”. The team can then turn off their robot, but they must not move it. The time at which the robot is stopped would be recorded as the final time. The team must not enter the arena until referee has acknowledged the “STOP”

7.9.4 For each retry, robots must be started again from the start point. Points will reset to zero.

7.9.5 Arena Management team is responsible to reset the arena, any team member is not allowed to interfere or do the resetting of arena themselves. If such an act is done, referee will call retry.

7.9.6 Separate time for individual retries will NOT be recorded or maintained. When a team takes a retry, it is only allowed to restart the robot.

7.9.7 Once the start whistle is blown the team can reprogram their Robot, however no extra time shall be given to the teams.

7.9.8 If the contestants enter the arena during the match, it will automatically be counted as a retry.

7.10 DISQUALIFICATION

The following behavior shall be considered for disqualification by the referee and the team could possibly be disqualified:

7.10.1 Attempting to damage the game field.

7.10.2 Performing any act that fails to comply with the spirit of Fair Play

7.11 PROTEST PROCEDURE

The protest procedure is as follows:

7.11.1 The team must launch a protest (submit a complete protest form to the head jury) within 15 minutes of the end of their match.

7.11.2 The team must collect the protest form from the head jury on request or use a hard copy of the form in Anx D.

7.11.3 The team must submit a non-refundable protest fee of Rs. 5000/- along with the protest form.

7.11.4 A complete protest form includes submission of the protest fee.

7.11.5 The head jury will forward the case to the judges.

7.11.6 The judges will decide on the protest’s validity and render their decision.

7.11.7 The judges’ decision will be final and In case of noncompliance of any of points above the protest will not be considered valid.

8 TEST RUN

Contestants will be given time for trial run one day before the contest to calibrate their robot/sensors on the actual arena/game field.

Annex A: COMPONENTS LIST

Please see the components below. In case of any query, questions shall be emailed to NERC Coordinator at nerc@ceme.nust.edu.pk . The FAQs section on the website shall be considered part of the theme.

Table 3 Components List

Sensors	***Allowed Parts***
Wall Sensor (Proximity Sensors)	1) IR Sensors: Sharp GP2Dxx & GP2Y0xx series sensor 2) Sonars: Maxbotix Maxsonar Range Finder series (XL,LV) Parallax PING))) Ultrasonic sensor, HC-SR04 3) Self-made from discrete components
Colour Sensor	1) ADJD-S371-QR99 RGB sensor 2) Self-made from discrete components 3) TCS230 or TCS3200
Other Sensors	1) Compass/Magnetometer: HMC5883L 2) IMU: MinIMU-9 v3 Gyro Accelerometer and Compass (L3GD20H and LSM303D), MPU-6050 Accelerometer + Gyro 3) IMU: GY-80 ADXL345 Accelerometer 4) Accelerometer : ADXL345 5) Gyro: LPR550AL Dual-Axis (Pitch and Roll or XY) Gyro ,LPR550AR Dual-Axis (Pitch and Roll or XY) Gyro
Microcontroller	1) PIC16F/PIC18F family 2) AVR ATTiny, ATMega, 3) 8051, 8052, 8055

Development Boards	1) Arduino Mega, Uno, Nano, mini, Pro Series, Leonardo, Esplora, Due 2) Pinguino 26j50 3) Amicus 18
External Shields	*Only SD card shield allowed*
Motor driver	*Self-made from discrete components*
Motor	*Maximum 2 motors are allowed for the drive purpose There is no limitation of number of motors in mechanism. Encoders may be attached externally*
Battery	*Any type (Power Banks are allowed)*
Wheels	*Meccanum/Omni wheels are not allowed*
IR Sensor	*BRD1000 Array Sensor*

.

Annex B PROTEST FORM

Protest Form

Team Name:	
Team ID:	
Team University:	
Team Members:	
Match finish time (to be filled by Head Jury)	
Launch time of Protest (to be filled by the head jury)	
Protest fee Payment (to be filled by head jury)	

Reason of Protest: _____

_____

_____

_____

_____ _____

Signature of Team Leader Signature of Head Jury

Decision of Judges: _____

_____

_____

_____

_____

Signature of Head Judge

Annex C TREE DIMENSIONS AND COMPLETE DIAGRAM

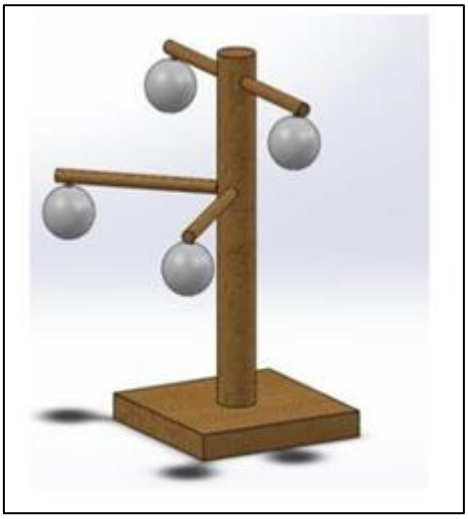

Figure 2. Side View of Tree

The ball is attached with the magnet to the tree. Specifications of the magnet are given in the link below:
*https://www.evselectro.com/strong-n50-rare-earth-neodymium-ring-magnets-3mm-hole-10x3mm-7111?search=Magnet&page=2

Characteristics of the Ball

Color: Green or Orange
Double Circle (Brand of DHS) Classic 40mm Table Tennis Balls –
Standard Plastic Balls
Diameter = 40 mm
Weight of each ball = 2 – 3 grams each
Manufacturer www.dhs-sports.com

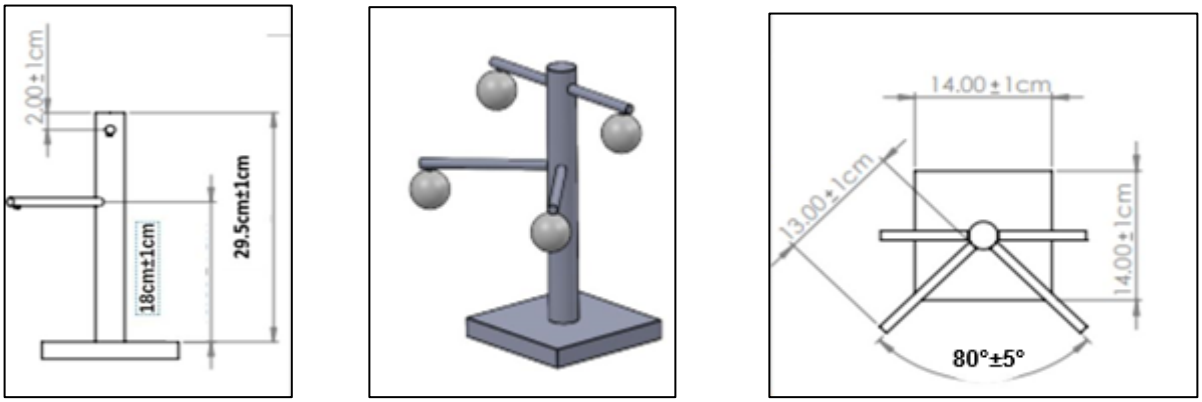

Figure :3 Representation of Hanged Balls

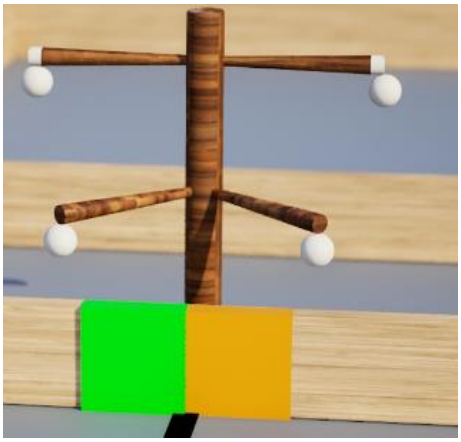

Figure 4: Representation of the label

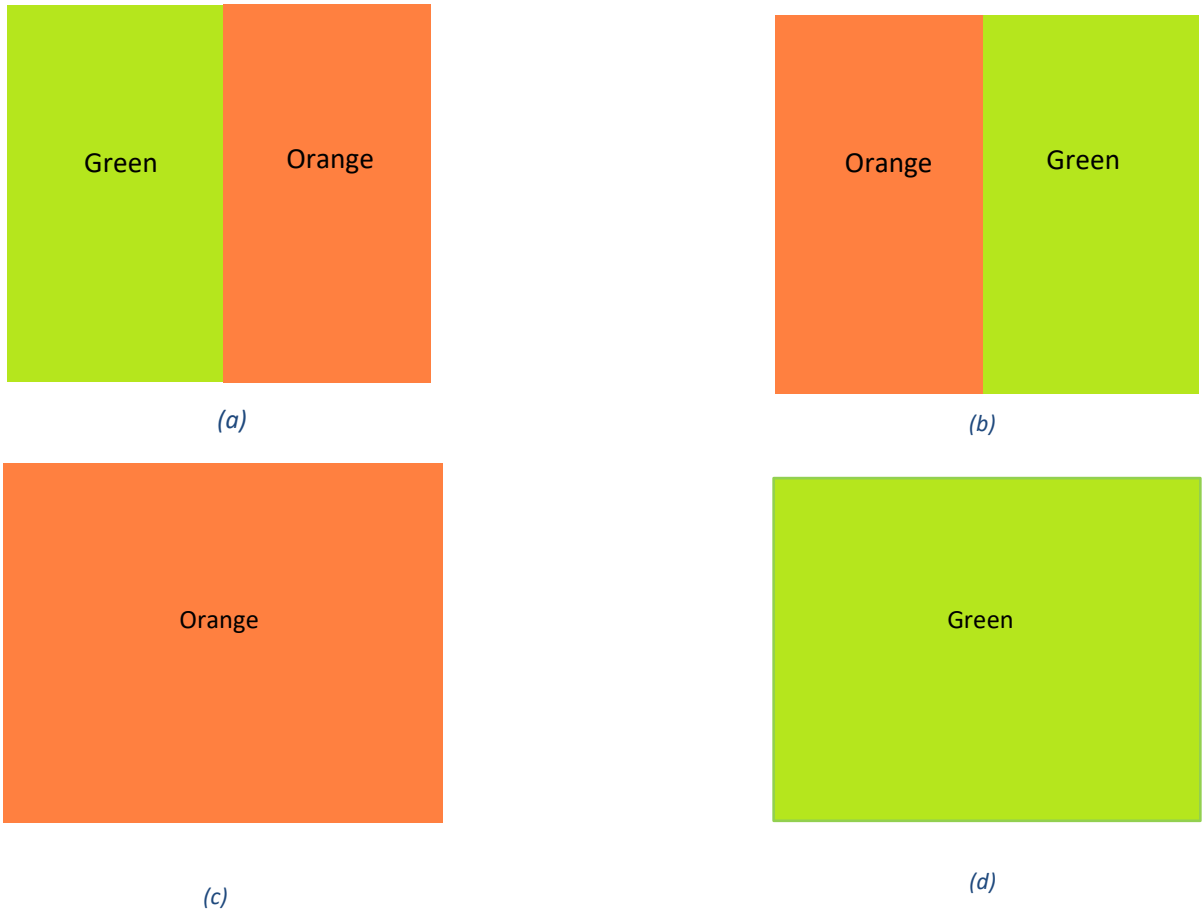

Fig. 4. Representation of the label present in front of each tree (as shown in Fig 4) (a) Left half is green representing the unriped fruit on the left side of tree and right side is orange representing ripened fruit on the right side of the tree (b) Left side is orange representing ripened fruit on the left side of the tree and right half is green representing unriped fruit on the right half of the tree (c & d) Both halves are of the same color (Either orange or green) representing either ripened fruit or unriped fruit on both sides if the tree respectively.